Exchange Rate and Determinants in China

By

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ABSTRACT

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As a result of the rapid development of China's economy, the exchange rate of RMB has drawn the world's attention. Particularly in recent years, the discussion on revaluating RMB has been a prevailing topic among many scholars. There are two main methods to evaluate the movements of exchange rate, which are PPP and ERER methods respectively. The empirical results show that PPP relationship of RMB-USD is not supported confidently and powerfully presumably because of the productivity difference between China and USA. Then according to the ERER method the equilibrium real exchange rate of RMB is found and by comparing ERER with REER of RMB we can observe the deviation of real exchange rate of RMB from the equilibrium real exchange rate, especially the obvious undervaluation in recent two years, which means that China has to reform its exchange rate system so that China is able to expedite the economic progress in the future.

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INTRODUCTION

In international monetary economics, the analysis of exchange rate has been a perennial topic. In case of China's RMB, the controversy over the value of RMB always exists. Just not a while ago, people were still talking about the depreciation expectation to RMB, but all of a sudden the market expectation to China's RMB switches from one side to the other. Some people say that China's RMB is undervalued and ask for the revaluation. Then this paper focuses on China's exchange rate and its determinants.

Section I briefly introduces the background on China's exchange rate, including the development history and the current exchange rate regime. From 1949, China started liberalizing her exchange system, especially during the period of 1990s. On December 1st, 1996, China officially agreed to make RMB fully convertible for current account transactions and now China has already made progress on the way to the liberalization of capital account.

Section II presents the theory of purchasing power parity and its empirical application in the relationship of RMB and USD. The theory of purchasing power parity (PPP) is an academic orthodoxy to determine a country's exchange rate fundamentally. Since 1922 when Cassel proposed the notion that exchange rates should tend to equalize relative price levels in different countries, people have been devoted into finding the empirical evidence to this theory. This paper attempts to find whether RMB-USD PPP relationship holds by using the cointegration method that is based on the approach of Engle-Granger's (1987) single equation. Because ADF test to the residuals obtained from the cointegration equation cannot be rejected, we

cannot simply use PPP relationship of RMB-USD to determine the equilibrium exchange rate of RMB.

Consequently, besides purchasing power parity theory, Section III also discusses the empirical model of real effective exchange rate (REER). Edward (1989) first provides the extensive analyses of REER for the case of developing countries in the theoretical and empirical perspectives. And Elbadawi (1994) develops a simplified version of Edwards' model for the estimation of long-run equilibrium exchange rate. In reference to these models, Section III uses the single-equation approach to implement the empirical research for China's REER, including the selection of fundamental factors, estimation of long-run equilibrium real exchange rate (ERER), etc. The brief explanation of econometric results is considered in Section 3.6 and 3.7. Finally, conclusion appears in Section IV.

I. BACKGROUND ON CHINA'S EXCHANGE RATE

1.1 DEVELOPMENTS OF CHINA'S EXCHANGE RATE SYSTEM

Like most developing countries, China's exchange rate system has experienced the evolution from the strict foreign exchange control to the relatively flexible exchange administration. Generally speaking, there are three main development periods in the history of China's exchange system.

Strict Foreign Exchange Control from 1953 to 1978

During this period, China was in the environment of highly centered and planned economy. Due to the shortage of the foreign exchange resources in this period, China implemented rigid foreign exchange control. All foreign exchange receipts were obliged to be submitted to the government and any purchase of foreign exchange

should be included in the national plan.

Transitional Period for Liberalization from 1979 to 1993

While China has been establishing the market economy since 1978, China has also been reforming her foreign exchange system to make it more appropriate to China's economic developments. First of all, the central government progressively relaxed the tight control on international transfer of funds by allowing different parties (including trade companies and individuals) to keep a proportion of foreign exchange. And the authorized parties could trade their foreign exchange through Bank of China on the supervision of People's Bank of China. From 1981 to 1984, China practiced a dual exchange rate system: the official rate and the internal settlement rate. The two rates were unified at the latter rate on 1st January 1985.

However, the dual exchange rates reappeared in late 1986, because Foreign Exchange Adjustment Centers (FEACs or swap centers) began to run in several cities, where the exchange rates, mainly determined by the market force, were quite deviated from the official rate, overvaluated disproportionately to the increase of the domestic prices. On April 9th, 1991, China began to adopt a "managed floating" system to adjust the official rate "continuously" and "in small steps", which is regarded as better than the previous discrete large adjustments.

In 1991, this system went on pretty well, which actually provided a gold opportunity for China to unify her multiple exchange rates. Nonetheless, the economy began showing signs of overheating in 1992, which brought about more pressure on RMB to be depreciated and triggered the momentous reforms of China's foreign exchange in the third period.

The Liberalization Reforms since 1994

On January 1st, 1994, China made RMB conditionally convertible for the current account transactions and the dual exchange rates were unified into a single managed floating exchange rate, which was 8.70 Yuan per USD, on the basis of market demand and supply. A unified and standard inter-bank foreign exchange market, that is, China Foreign Exchange Trade System (CFETS) was established. Furthermore, on December 1st, 1996, China officially accepted the obligation of Article VIII of the IMF Articles of Agreement and made RMB completely convertible for the current account transactions.

Besides, not only did China further relax her restrictions on export receipts and import payments, but also the foreign exchange forward contracts were introduced. Domestic residents are gaining more and more freedom to trade and use their foreign exchange deposits. For example, since February 2002, domestic investors have been allowed, with their foreign currency deposits, to purchase B shares (denominated in USD and HKD), which were only opened to foreign investors before. More importantly, since the end of 2002 Qualified Foreign Institutional Investors (QFII) have been authorized and foreign institutional investors can invest domestically in A shares (denominated in Yuan), which is regarded as one of the milestones for China to liberalize her capital account further.

1.2 CURRENT EXCHANGE RATE REGIME IN CHINA

General Issues on Exchange Rate Regime

The term of exchange rate regime refers to an operational framework for exchange rate management. By this operational framework, a country's authority can accomplish the optimal exchange rate management so that the exchange rate regime is

able to facilitate its economic development. Over the past century the menu of exchange rate regimes has evolved considerably. In today's world a country can find various choices of exchange rate regime that can basically be classified as the kind of pegged regime in one extreme and the kind of fully floating regime in the other extreme.

Naturally, countries will shift their choices of exchange rate regime whenever their authorities think that the shift is necessary for their economic development. As a matter of fact, it is quite difficult for a country to choose its niche regime, which involves the consideration of external balance, internal balance and some structural features of the economic system.

Usually a country will try to tailor its exchange rate regime to achieve its external as well as internal objectives, such as balance of payments, inflation and price stability, etc. Unfortunately, there is not such an exchange rate regime that can insulate a country's economy from both the external and internal shocks simultaneously. That is, you cannot have the fixed exchange rate, free capital mobility and price stability in hand at the same time. Thus, the specific choice of exchange rate regime will be dominated by the type of the shocks influencing a country's economy. A fixed exchange rate places an international constraint on national economic policies, while a flexible one may keep the domestic economies free from the international constraints. In this sense, a floating exchange rate regime will insulate the national economy from the external shocks.[①] As to the internal shocks, domestic real shocks (goods-markets) call for exchange rate flexibility, while domestic nominal shocks (money-markets) require fixed exchange rates. Besides, some structural characteristics of an economy also play an important role on the choice of exchange rate regime, such as the extent

[①]Richard C. Barth & Chorng-Huey Wong. *Approaches to Exchange Rate Policy*. IMF 1994.

of an economy's openness, the state of development of foreign exchange market and monetary or securities markets in an economy, the management capability of a country's central bank, and the soundness of domestic banking system in an economy, etc.

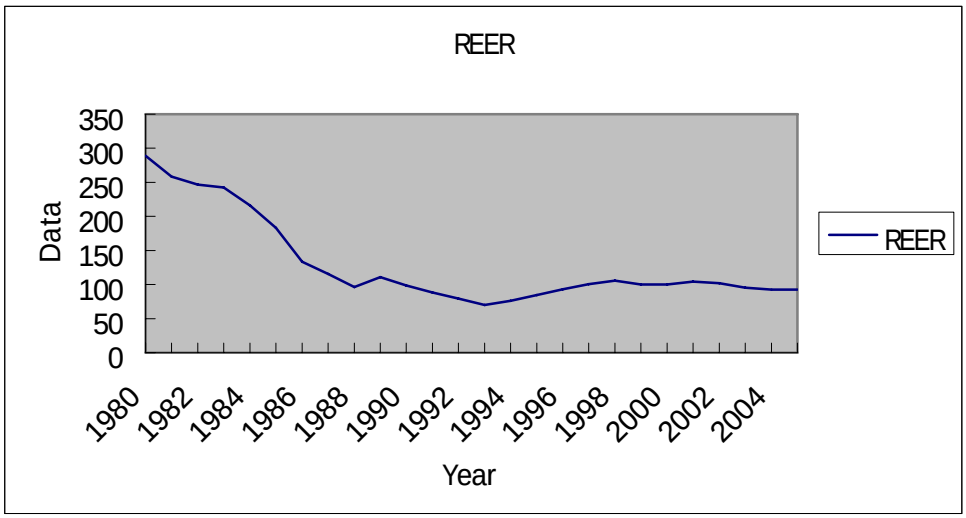
Current Exchange Rate Regime in China

China's exchange rate regime has also changed a lot with the economic developments. Before 1991, the exchange rate regime in China was a purely fixed one, though sometimes the government would devaluate exchange rate based on the domestic economic conditions. And because those adjustments were discrete and usually quite lagged behind the economic changes, they themselves became a kind of "shocks" to the national economic developments. Then China shifted her exchange rate regime from a fixed one to a managed floating one in 1991, hoping that the exchange rate would fluctuate more gently and smoothly.

From 1994 to 1997, China's managed floating exchange rate regime held well and RMB gradually appreciated from 8.7 Yuan per USD to 8.3 Yuan per USD. The de jure regime is consistent with the de facto one. Then it was Asian Financial Crises when several Asian countries were forced to give up their fixed exchange rate regimes and depreciate their currencies, while China promised not to depreciate RMB and pegged RMB to USD at 8.27 Yuan per USD with the fluctuation band less than 1%. From then on, China has been keeping this exchange rate regime. Thus, IMF classifies China to a de facto conventional fixed peg regime instead of a managed floating regime. However, with the economic development the market pressure requires China to change her de facto conventional fixed peg exchange rate regime, but to implement more flexible policy to fuel China's reform for the framework of exchange rate. Then on 21st July 2005, China declared that the exchange rate of RMB gave up pegging on

the price of US dollars, but began to refer to the prices of a basket of currencies based on the demand and supply of the exchange market. From that day, the exchange rate of RMB quoted by banks in China is about to change every day and even to be different in a day. That is, China is endeavoring to make the exchange rate of RMB more flexible, and preparing to liberalize the exchange rate of RMB completely at last. Figure 1 shows the real effective exchange rate of RMB to USD from 1980 to 2005.

Figure 1 Real Effective Exchange Rate of RMB to USD 1980~2005



Source: International Financial Statistics

II. RMB-USD PURCHASING POWER PARITY RELATIONSHIP

2.1 BASIC CONCEPTS AND DEFINITIONS

The rudiments of the PPP idea can be dated back to the sixteenth century, but British economist, David Ricardo, in nineteenth century and Swedish economist, Gustav Cassel, in 1920s, popularized this idea and made it the keynote of the theory of exchange rate.

Basically, the PPP relationship can be expressed as $E_{H/F} = \frac{P_H}{P_F}$, which is also called

as absolute purchasing power parity. In this formula, $E_{H/F}$ denotes exchange rate in terms of Home currency per unit of Foreign currency, P_H is the price of a reference commodity basket sold in Home and is denominated in Home country's currency, and P_F is the price, denominated in Foreign country's currency, of the same basket sold in Foreign.

The absolute PPP relationship also implies the proposition of relative PPP, which states that the percentage change in the exchange rate between two countries' currencies over any period equals the difference between the percentage changes in two countries' national price levels, that is, $(E_{H/F,t} - E_{H/F,t_0}) / E_{H/F,t_0} = \pi_{H,t} - \pi_{F,t}$, where π_t denotes inflation rate in Home or Foreign at time t ($\pi_t = (P_t - P_{t_0}) / P_{t_0}$).[①]

There are some preconditions for the PPP relationship to hold between any two currencies, such as price indices for internationally identical baskets of goods, free trade without trade barriers and restrictions, perfectly free competitive markets across countries, etc. But the real world is impossible to be this kind of paradise and then it is not surprising for us to see quite a lot of unsatisfactory empirical evidence to the PPP relationship. Nonetheless, since 1920s the empirical techniques have been improved quite a lot, which facilitates people to prove this theory.

Some economists scrutinized the PPP theory and generalized a long-run model of exchange rate determination. They defined the term of real exchange rate (RER), expressed as $q_{H/F} = (E_{H/F} \times P_F) / P_H$. Here $q_{H/F}$ denotes the real exchange rate and $E_{H/F}$ denotes the nominal exchange rate. Moreover, Edwards (1989) explicated the real exchange rate for developing countries at the first time and defined it as the ratio of the tradable price to the nontradable price, that is:

[①]Paul R. Krugman & Maurice Obstfeld. *International Economics Theory and Policy*: P391

$$q_{H/F} = P_{tradable} / P_{nontradable} = (E_{H/F} \times P_T^*) / P_N .$$

In the practice, consumer price index (CPI) is a proxy of nontradable price and wholesale price index (WPI) or producer price index (PPI) or export price index is a proxy of tradable price. Qingying Kong (2000) articulates that export price index is the best proxy for tradable price, compared to WPI and PPI at testing the PPP relationship for the movements of Yen/DM.

2.2 EMPIRICAL RESEARCH EVOLUTION

In the first stage, most studies focused on the test of simple purchasing power parity as the null hypothesis. The theoretical model is based on the formula of $E_{H/F} = \frac{P_H}{P_F}$.

Typically, Frenkel (1978) ran regressions of the form of $e_t = \beta_0 + \beta_1 (p_t - p_t^*) + \mu_t$, where e_t, p_t and p_t* is respectively the logarithm of $E_{H/F}$, P_H and P_F, and tried to test the null hypothesis whether the slope coefficient of β_1 was one. Krugman (1978) and Frenkel (1981) re-estimated the equation using instrumental variables and their methodology succeeded because it yielded coefficients quite closer to one than under simple OLS. However, the fundamental flaw for the first stage tests was not considering the possible nonstationarity of relative prices and exchange rates.

Then from the second stage, the tests were put into the context of cointegration methodology (Engle and Granger 1987, Johansen 1988). The tests in both second and third stage are based on the concept of real exchange rate. In stage two, tests focused on the hypothesis that the logarithmic real exchange rate in the equation of $e_t = p_t - p_t^* + \mu_t(q_t)$, is stationary and the equation had the restrictions that the coefficients of p_t and p_t^* were equal to one at the same time. Most of the tests in this stage support the hypothesis that the real exchange rate is random walk (e.g.

Adler and Lehmann (1983), Darby (1983)). The problem of this stage is that the tests are not powerful enough because sometimes it is difficult to tell the slow mean reversion from random walk. Cheung and Lai (1993) found the support for long-run PPP after correcting the measurement error and they also advocated the unrestricted tri-variate model that means p and p* will enter into the equation separately, not in the form of (p-p*), which is bi-variate.

Therefore, in the third stage, the tests started to concentrate on the hypothesis that the real exchange rate in the equation of $e_t = \mu p_t - \mu^* p_t^* + \mu_t(q_t)$ is stationary. μ and μ^* can be any constant, which relax the symmetry and proportionality restrictions in stage two. With the help of Johansen's (1991) technique, empirical research (Frankel and Rose 1996, Clark and MacDonald 1998, etc) in stage three highlights that the real exchange rate is mean-reversed in the long run.

2.3 EMPIRICAL STUDY ON RMB-USD PPP RELATIONSHIP

Model and Data

This section follows the model in stage three. That is, the test focuses on the hypothesis that the real exchange rate in the equation of $e_t = \mu p_t - \mu^* p_t^* + \mu_t(q_t)$ is stationary without restrictions on the coefficients of μ and μ^* in the context of single-equation cointegration approach.

Here exchange rate (ER) refers to the nominal exchange rate of RMB per USD. As a matter of fact the real exchange rate should be used in this model instead of nominal exchange rate. And according to the definition of Edwards (1989) the real exchange rate should be computed based on the ratio of tradable price and nontradable price, that is, $q_{H/F} = P_{tradable} / P_{nontradable} = (E_{H/F} \times P_T^*) / P_N$, where CPI is the usual proxy of

nontradable price and export price index is the usual proxy of tradable price. Unfortunately it is impossible to find quarterly data for China's export price index, so this paper has to assume that the nominal exchange rate is the best substitution to the real exchange rate of RMB to USD. Similarly domestic price of China refers to the consumer price index of China (CPIC) due to the same reason and foreign price refers to the export price index of USA (EXPUS). Meanwhile, LER, LCPIC and LEXPUS are all the logarithmic forms of the variables of ER, CPIC and EXPUS. Therefore, based on the equation of $e_t = \mu p_t - \mu^* p_t^* + \mu_t(q_t)$, the model used in this paper can be described as $LER_t = \mu LCPIC_t - \mu^* LEXPUS_t^* + \varepsilon_t$, where the error term ought to be stationary.

The data used for this section comes from the International Financial Statistics (IFS), including quarterly data of nominal exchange rate of RMB per USD, CPI of China and U.S.A., export price index of U.S.A from 1990 to 2002.

Econometric Result

First, check the stationarity of each variable by ADF test. All the variables are not stationary on the I(0) level, but become stationary after the first difference. The results are showed in Table 1.

Table 1 Stationary Tests for PPP Model

Variables	ADF test without trend		ADF test with trend		ADF test on the first difference			Order of Integration
	Test Value	p-value	Test Value	p-value	Test Value	p-value	Lag	
LER	-2.000	0.2865	-1.561	0.8062	-7.005	0.0000	0	I(1)
LCPIC	-0.564	0.8805	-1.268	0.8948	-4.020	0.0013	0	I(1)
LEXPUS*	-1.612	0.4768	-0.966	0.9486	-3.337	0.0133	0	I(1)

** Nagayasu (1998) proves that the export price is better than CPI and WPI in the study of PPP relationship. But for China we can only find the quarterly data of CPI. Even though we substitute CPI for EXP of America, the result deteriorates actually.*

Then these variables are qualified to run a cointegration regression and the

econometric results are showed in Table 2.

Table 2 Econometric Results of PPP Model between RMB and USD

	LCPIC	LEXPUS	Constant
Coefficients	-0.386	5.337	-20.552
t-value	-1.32	7.44	-6.20

From Table 2 we can see that the econometric results are not satisfactory because not only both signs of the coefficients of LCPIC and LEXPUS are not congruent with the theoretical expectation, but also the error term is not stationary by the ADF test. Furthermore, t test also shows that the coefficient of LCPIC is not significant on the confident level of 5%. Consequently the real exchange rate between RMB and USD is not stationary and PPP relationship of RMB-USD is not supported confidently and powerfully.

2.4 IMPLICATIONS OF THE ECONOMETRIC RESULT

Yi Gang & Fan Min (1997), Zhang Xiaopu (2000) and Wang Zhiqiang, Qi Peijin, Sun Gang (2004) all thinks that there are grave theoretical limitations for PPP model to analyze the movement of exchange rate of RMB because actually PPP theory just describes the relationship of two currencies in the ideal conditions that cannot be satisfied for most developing countries like China. Such countries as China are experiencing dramatic fundamental changes which cannot be reflected in PPP model, but these changes are truly able to influence the movement of equilibrium exchange rate. And as we mentioned above, PPP model requires that tradable price be used to evaluate a currency's exchange rate, but for countries like China it is quite difficult or even impossible to obtain this kind of data. Naturally it is not credible to study RMB's exchange rate in the context of PPP theory. Yi Gang and Fan Min (1997) also showed that neither the absolute PPP theory nor the relative PPP theory and interest rate parity

theory were suitable for the study of China's exchange rate. Balassa (1964) and Samuelson (1964) also argued that productivity difference between developed and less-developed countries would result in the quite deviation from the PPP relationship. That's why we cannot confidently determine the equilibrium exchange rate simply based on PPP relationship of RMB-USD. Consequently, Section III explores another methodology to determine the equilibrium exchange rate of RMB.

III. EQUILIBRIUM REAL EXCHANGE RATE OF RMB

3.1 DEFINITIONS AND MEASUREMENT

In the theory of PPP, the nominal exchange rate (NER) and real exchange rate (RER), defined by the relative price between Home and Foreign, are both single exchange rates between the domestic currency and the foreign currency without considering the impact coming from the third country. Effective exchange rate (EER) is a weighted exchange rate index, with the weights typically using the bilateral trade value between home country and its trading partners and competitors in the local economy.

If we use nominal exchange rate to calculate the EER, we will get the nominal effective exchange rate (NEER) with the formula of $NEER = \sum_i (\frac{Trade_{Fi}}{Trade_H} \times \frac{E_{Fi}}{E_{0i}} \times 100)$, where $Trade_{Fi}$ denotes the sum of exports and imports of a sample foreign country to Home country, $Trade_H$ denotes the total of exports and imports of Home country to all sample foreign countries in a period, E_{Fi} denotes the bilateral exchange rate of a sample foreign country to Home country, and E_{0i} denotes the bilateral exchange rate of a sample foreign country to Home country in the base period. Meanwhile, if we combine NEER with the price level in different

countries, we will get the real effective exchange rate (REER) with the formula of $REER = NEER \times \frac{P_H}{P_W}$, where P_H denotes Home country's price index, typically consumer price index (CPI), and P_W denotes the price index in the world, which is the trade-weighted consumer price index among the trade partners and competitors[①]. Here E_{Fi} and E_{0i} are defined in terms of Foreign currency per unit of Home currency, so a rise of NEER or REER indicates a nominal or real effective appreciation of home country's currency.

3.2 LITERATURE REVIEW

In the context of purchasing power parity, the equilibrium exchange rate is a long-term concept. The real exchange rate doesn't need to be fixed, but it should be stationary. And as the section II mentioned, most empirical studies in the third stage support mean-reversing real exchange rate, that is, the real exchange rate will return to its mean in the long run and this mean is regarded as the equilibrium real exchange rate that is fixed. However, in this model the parlance of equilibrium real exchange rate only refers to the domestic and foreign prices, which sometimes is thought to be too simple to be credible. Of course, we can prove that there exists cointegration relationship between the exchange rate and relative price of domestic to foreign, but it doesn't necessarily lead to the conclusion that the equilibrium real exchange rate can be defined by this way. For example, maybe the problem of omitted variables also has a vital impact on determining the equilibrium exchange rate. Then different models are developed to include other variables (proxies of fundamentals), where equilibrium real exchange rate is defined as a function of those fundamentals.

① Details can be seen in the notes of International Financial Statistics (IFS).

Williamson (1985) first popularized the idea of fundamental equilibrium exchange rate (FEER). After that the literature on this idea has grown considerably. FEER is a real effective exchange rate (REER) that is consistent with the macroeconomic balance, i.e. simultaneous achievement of internal balance and external balance. This REER will bring balanced current account with a sustainable desired net flow of capital to this country, which is identified as external balance, while at that point the determinants of the current account have been set on the level of output in line with both full employment[①] and a low and sustainable inflation rate. Because those determinants are termed as "fundamentals", FEER is entitled this name for abstracting from the short-run factors. FEER under this concept won't change as long as the positions of internal and external balance are undisturbed.

Williamson (1994) introduced the method to calculate FEER, which requires considerable parameter estimation and judgment, such as current account model, potential output, capital account, etc. Even though the FEER approach provides a transparent and systematic way for policymakers to assess exchange rates based on equilibrium or sustainable current account position, the economic fundamentals are those desired ideal economic conditions, which may in fact never be realized in the future. In this sense, the concept of FEER is actually normative than positive and it is also termed as desired equilibrium exchange rate (DEER) by Tamim Bayoumi *et al* (1994).

Stein (1994) also expounds the model of natural real exchange rate (NATREX), which

① The concept of full employment refers to non-accelerating inflation rate of unemployment or NAIRU, which is also called as natural rate of unemployment.

is defined as the rate that will prevail if speculative and cyclical factors could be removed while unemployment is at its natural rate. As a matter of fact the essence of these concepts is basically identical, but somewhat different explanation to the fundamental things. And it is worthwhile mentioning that the models above are mainly applied to the developed countries.

Edwards (1989), in one of his seminal works, provided an extensive theoretical and empirical analysis of the factors affecting equilibrium real exchange rate (ERER), specifically for developing countries. Edwards (1989) classifies the fundamentals that will affect the real exchange rate into two types: external and internal ones. International prices, international transfers and world interest rate are included in the external fundamentals. Term of trade (TOT) is the proxy of international trade and foreign aid is used to measure the international transfers. Interest rate in United States is regarded as the world interest rate for the small developing countries. Internal fundamentals are also classified into two kinds, one of which is policy-related, such as import tariffs, import quotas, export taxes, exchange and capital controls, composition of government expenditure and so on; the other of which is non policy-related, mainly including technology progress. In Edwards' model, the policies related with the real exchange rate are international trade policy and fiscal policy. Edwards regards the change from tariff, term of trade and capital flows as long-term and real disturbances to the equilibrium real exchange rate. Higher import tariffs and more capital inflows will result in a real and long-term equilibrium appreciation. Nevertheless, the impact from the term of trade as well as government consumption is ambiguous to the long-run equilibrium real exchange rate. The improvement of TOT or the increase of government consumption can bring a real equilibrium appreciation as long as the income effect of TOT improvement will dominate the substitution effect and

government tends to have a higher propensity to spend more on nontradable goods. The change of monetary policy will definitely influence the actual real exchange rate. For example, the expansionary monetary policy may lead to the overvaluation of the country's currency, that is, the actual real exchange rate is not identical to the equilibrium real exchange rate. Edwards defines it as a misalignment if this departure of short-run real exchange rate from the long-run equilibrium real exchange rate is not short-lived, but sustained. He thinks that the overvaluation induced by the expansionary monetary policy will not stand a long time, because the fundamental forces will guide the real exchange rate to move back to the equilibrium real exchange rate. Then this kind of policy is usually regarded as the nominal disturbance rather than the real disturbance to the equilibrium real exchange rate.

Elbadawi (1994) develops a simplified version of Edwards' model for the long-run equilibrium exchange rate and makes it easier to run. Elbadawi includes the fundamentals of nominal domestic absorption to GDP, TOT, export tax, import tax, government consumption on nontradable goods and government expenditure to GDP to determine the equilibrium real exchange rate. Also he uses the openness, which is measured by the ratio of imports plus exports to GDP, as a proxy of export tax and import tax. To eliminate the endogenous problem of the variable of nominal domestic absorption, he specifies an equation linking private absorption to the sustainable level of net capital inflows and to the real consumption rate of interest. Finally, he gets a reduced-form dynamic equation for the real exchange rate with the variables of TOT, openness, ratio of net capital inflows to GDP, government consumption on nontradable goods, and ratio of government expenditure to GDP.

Compared to FEER model, which requires the estimation and judgment of optimal or sustainable values for all the explanatory variables, ERER model, developed by

Edwards and Elbadawi, concentrates more on studies of how particular values of these fundamental variables affect the equilibrium exchange rate in a pragmatic way. In this sense, the methodology and model used in this paper are closely based on the idea from Elbadawi (1994).

3.3 METHODOLOGY

The alternative approaches besides PPP define the equilibrium real exchange rate as a function of some fundamentals, which to some extent determine the movement of equilibrium real exchange rate. Meanwhile, the equilibrium real exchange rate is in fact unobservable, which makes the problem more complicated and challenging, so economists try to find the co-integrative relationships between fundamentals and equilibrium real exchange rate, which can be exploited to observe the equilibrium real exchange rate.

Actually, there are several methods used by the economists to test the co-integrative relationships between the fundamentals and real effective exchange rate, among which the single-equation method of Engle-Granger (1987) and the full-equation method of Johansen (1988) are most popular. Chueng & Lai (1993) suggests that Johansen's maximum likelihood technique for testing and estimating co-integrative relationships performs better than the single-equation method. Some argue that Johansen's method has obvious and significant power advantage over the Engle-Granger's method because the former examination and estimation are based on the full system and multiple equations. Even though this kind of argument is true, the single-equation method is still quite useful in the practice, because the Johansen's full-equation method is too sensitive to the lag selection and is lack of power for the small finite samples. Due to these reasons, the single-equation method of

Engle-Granger (1987) becomes more appropriate to the data of this paper.

In this single-equation method, a linear relationship between the equilibrium real exchange rate and the fundamentals in the long run is assumed and this relationship is expressed as $\ln e_t^* = \beta_0 + \beta_i F_{it} + \varepsilon_t$ (1), where e_t^* is the equilibrium real exchange rate, F_{it} is the vector of fundamentals (i=1, 2, ……, m) at time t, β is the vector of long-run coefficients, and ε_t is the error term. First, we are interested in the vector of long-run coefficients. We have to find these parameters' value by running regression between the real effective exchange rates and the values of fundamentals observed during some time periods. Although these variables of exchange rate and fundamentals themselves may not be stationary, the cointegration is still able to exist as long as they are stationary after the first difference, that is, they are I(1) order of integration, and the stochastic term after the regression is also stationary with a zero mean. Otherwise the coefficients from the regression will be spurious.

There are several methods to test the stationarity of the variables as well as the error term, such as Augmented Dickey-Fuller (ADF) unit-root test, Phillips-Perron unit-root test and so on. Since ADF is the most often used, this paper also follows this routine. If the null hypothesis of non-stationary variable can be rejected, then a steady state relationship between actual values of real exchange rate and fundamentals can be announced.

According to Elbadawi's forward-looking ERER model, from the equation

$$\ln e = \beta_0 + \beta_1 \ln(TOT) - \beta_2 \ln(OPEN) + \beta_3 \ln(\frac{A}{GDP}) + \beta_4 \ln(\frac{G \cdot EXP}{GDP}) + \beta_5 \ln(PRO) \quad (2)$$

and $\ln(\frac{A}{Y})_t = \alpha_0 + \alpha_1(\frac{NKI}{Y})_t - \alpha_2(\ln e_{t+1} - \ln e_t)$ (3), we can obtain the following reduced-form dynamic equation for the real exchange rate:

$$\ln e_t - \lambda_t \ln e_{t+1} = \delta_0 + \delta_1 \ln(TOT)_t - \delta_2 \ln(OPEN)_t + \delta_3 (\frac{NKI}{GDP})_t + \delta_4 \ln(\frac{G \cdot EXP}{GDP})_t + \delta_5 \ln(PRO)_t \quad (4)$$

In equation(2) the variables of TOT, OPEN, A/GDP and G• EXP/GDP are the fundamentals selected by Elbadawi. Another variable of $\log(\frac{Curr \cdot G \cdot EXP}{G \cdot EXP})$ is substituted by the variable of PRO because most empirical model including Elbadawi himself assumes that all the government expenditure are consumed on the nontradable goods, which implies that the variable of $\log(\frac{Curr \cdot G \cdot EXP}{G \cdot EXP})$ actually equals to zero.

In Elbadawi's model, the variable A is endogenous and can be specified by equation(3).

Furthermore, if the fundamental variables are stationary after the first difference, that is I(1), the following cointegration relationship also exists: $\ln \tilde{e}_t = \frac{1}{1-\lambda} \delta \tilde{F}_t + \eta_t$ (5).

In this equation e_t is the value of real exchange rate that satisfies equation(4) for sustainable values of the right-hand side variables, that is, equilibrium real exchange rate. This equation is identical to the basic ERER solution given by the basic model. This is a fundamental advantage of the I(1) and cointegration assumption, since it allows the derivation of a simple empirical framework from a much more complicated theoretical model. A practical approach to introducing the concept of "sustainability" on the part of the fundamentals is still needed. This paper uses moving average method to meet this end.

Firstly with a dynamic error correction equation of

$$\Delta \ln e_{t+1} = b_0 (\frac{1}{1-\lambda} \delta F_t - \log e_t) + b_1' \Delta F_{t+1} - b_2 \Delta \ln E_{t+1} + b_3 \Delta \ln MON_t + \varepsilon_{t+1}$$

the coefficient of error correction term, b_0, can be obtained. In the equation above

F_t are the fundamentals; E_t is the exchange rate in terms of domestic currency per unit of the foreign currency; MON_t is the ratio of domestic credits to real GDP that is the proxy of domestic monetary policy[①]. Next in order to eliminate the 99.9% (p) effect of an exogenous shock we can get the number of years (T) needed by calculating the formula of $1-p=(1-|b_0|)^T$. At last we can use the T-year moving average as a proxy of the sustainable fundamentals to estimate the equilibrium real exchange rate.

3.4 EMPIRICAL MODEL

Description of Fundamentals Selected

Then we select the following most important fundamentals in determining the behavior of the equilibrium real exchange rate of RMB:

(i) External term of trade (TOT): Term of trade (TOT) is the ratio of exports price index to imports price index. The improvement of TOT means that a country's exports price is relatively increased, but the imports price is relatively decreased. As a matter of fact, the impact of this improvement can be decomposed into substitution effect and income effect, which have totally different influence on the movement of equilibrium real exchange rate. The higher price of exports and lower price of imports will induce people to decrease their demand for exports but increase their demand for imports, which will naturally worsen the current account condition and then require a depreciation of equilibrium real exchange rate. Meanwhile, the same improvement of TOT does increase national income in terms of imported goods which in turn may

① According to Elbadawi (1994), monetary policy is only a short-term factor in terms of ERER.

increase the price of nontradables relative to exports that will require an appreciation of currency to balance the current account again. Most empirical studies in this field support the argument that the improvement of TOT will bring a real equilibrium appreciation, that is, the income effect in most cases dominates the substitution effect in the real world.

(ii) Ratio of net capital inflows to GDP (NKI): Value of net capital inflows is the capital account balance plus the error and omission item in Balance of Payment. The negative number for this variable means net capital outflows. The level of net capital inflows reflects the effects of capital control on the path of equilibrium real exchange rate. Capital control is modeled as a tax on foreign borrowing. Within this framework, more capital inflows are usually commensurate with the liberalization of exchange control and capital control, which will reduce the extent to which foreign borrowing is taxed, causing an appreciation of equilibrium real exchange rate. And also, adequate capital inflows may often heighten the price of domestic assets, which makes national residents feel that they are wealthier and tend to consume more in current period. As consumers increase their current consumption in all goods, including nontradables, there will be an incipient excess demand for nontradables and a subsequent increase in their relative prices, that is, an appreciation of real exchange rate.

(iii) Openness: It is calculated as the sum of imports and exports divided by GDP. This variable is a proxy of trade policy and trade liberalization, because it is not easy to accurately measure the value of import tariff, import quotas, export tax and so on. Generally speaking, the imposition of an anticipated import tariff will appreciate the real exchange rate because it will make imports more expensive and guide the consumers to substitute away from imports into nontradables, leading to an incipient excess demand for nontradables and a resultant increase of their relative prices, i.e.,

an appreciation of real exchange rate.

(iv) Government expenditure to GDP (GOVE): Actually, this variable should be decomposed into government consumption on nontradables and tradables. Obviously, the increase of government consumption on nontradables will generate the upward pressure on the prices of nontradables, which will lead to the appreciation of real exchange rate. However, if government consumes more on tradables, it is no doubt that the real exchange rate will depreciate. Since governments tend to spend most of their revenue on nontradables than the private sectors, this variable can be a proxy of government's consumption on nontradables. Then the increase of this ratio will lead to more demand for nontradable goods and thus an appreciation of real exchange rate.

(v) Productivity progress (PRO): This variable also measures the technology progress in a country. According to Balassa and Samuelson, labor productivity is higher in developed countries than less-developed countries and this difference occurs predominantly in the sector of the economy that produces the tradables rather than the sector that produces nontradables. This is because the tradable sector (comprising mainly of the manufacturing sector) has more latitude for productivity enhancing innovations and consequently, more opportunities for productivity gains. In contrast, it is inherently difficult for the non-tradable sector (of which the service industry makes up the main bulk) to enjoy similar productivity gains. One consequence of the Balassa-Samuelson model is that if traded goods' productivity relative to non-traded goods' productivity is growing faster at home than abroad, then the home country should experience an appreciation of the real exchange rate. One of the assumptions that this model rests on is that labor markets are competitive within each country, thus labor mobility leads to wage equalization between the traded and non-traded goods' sectors.

As for the measurement of productivity progress, the growth rate of real GDP is the usual proxy of this variable, such as Edwards (1989), Doroodian *et al* (2002), etc. This paper will follow their practice.

Data and Sources

The real effective exchange rate and most of the other values come from the International Financial Statistics (IFS). The value of TOT comes from the files of World Bank. This paper uses the annual data from 1982 to 2003. The measurement and definition have been described above.

3.5 ESTIMATION OF LONG-RUN EQUILIBRIUM

Six main variables is used in the empirical model, including REER, TOT, NKI, OPEN, GOVE, PRO. Based on the model described above, the variables of REER, TOT, OPEN, GOVE and PRO should be in the logarithmic form.

The first step is to check the order of integration in all relevant data set. As mentioned above, augmented Dickey-Fuller (ADF) unit-root test will be used to verify the possibilities for cointegration of all variables. Table 3 shows the test results.

Table 3 Test of Stationary for ERER Model

	ADF test on variables			ADF test on difference			Order of Integration
	test value	p-value	lags	test value	p-value	lags	
LREER	-3.143	0.0235	1	-2.670*	0.0795	0	I (1)
LTOT	-2.224	0.1976	3	-4.812	0.0001	0	I (1)
NKI	-3.678	0.0044	2	-4.296	0.0005	0	I (1)
LOPEN	-1.922	0.3217	1	-4.194	0.0007	0	I (1)
LGOVE	-3.832	0.0026	2	-3.616	0.0055	0	I (1)
LPRO	-3.620	0.0054	1	-3.897	0.0021	0	I (1)

** Null hypothesis of a unit root is rejected at the 10% level of significance, while others are all at the 5% or 1% level of significance.*

From Table 3 we can see that all the relevant variables are stationary after the first difference, that is I(1), even though these variables may be not stationary on I(0) level.

And then real exchange rate and its fundamentals are going to be cointegrated if the error term of the regression equation is also stationary. Since all the fundamental variables are stationary in first difference, that is I(1), equation(5), $\ln \tilde{e}_t = \frac{1}{1-\lambda}\delta \tilde{F}_t + \eta_t$, must be satisfied. Then by running the regression for equation(4),

$$\ln e_t - \lambda_t \ln e_{t+1} = \delta_0 + \delta_1 \ln(TOT)_t - \delta_2 \ln(OPEN)_t + \delta_3 (\frac{NKI}{GDP})_t + \delta_4 \ln(\frac{G \cdot EXP}{GDP})_t + \delta_5 \ln(PRO)_t$$

, we can get the coefficients of λ and δ i. After that we can test whether the error term for equation(4) is stationary by the ADF unit-root test. At last we are able to estimate the coefficients for the long-run equilibrium real exchange rate equation by calculating the value of $\delta_i / 1-\lambda$ whose results are showed in Table 4.

Table 4 Long-run Fundamentals' Coefficients

	LTOT	NKI	LOPEN	LGOVE	LPRO	Constants	λ
δ i, λ	0.589	0.004	-0.034	1.101	-0.099	-4.521	0.868
β_i	4.455	0.302	-0.254	8.302	-0.751	-34.113	
t-value*	2.56	2.31	-3.23	2.49	-1.25**	-3.33	7.18

** Significant at the 5% level*

*** Since the purpose of this study is to estimate ERER and compare them with REER, all the relevant variables which determine the long-run equilibrium value should be included, whether or not they are statistically significant.*[①]

Since the long-run coefficients for the equilibrium real exchange rate equation are computed, the estimate of the long-run equilibrium exchange rate can be found. First of all we should run the error correction equation of

$$DLREER = b_0 RESID + \beta_1' DLTOT + \beta_2' DNKI + \beta_3' DLOPEN + \beta_4' DLGOVE + \beta_5' DLPRO - \beta_6 DLE + \beta_7 DLMON + \varepsilon$$

to get the coefficient of error correction term and here we find that b_0 equals -0.73

[①]K. Doroodian, Chulho Jung and Ahmet Yucel. *Estimating the equilibrium real exchange rate: the case of Turkey*. Applied Economics, 2002.

which accords with Elbadawi's results for other developing countries whose coefficients in Elbadawi (1994) like Chili, Ghana and India were in the scope of 0.78 to 0.67[①]. Then by the formula of $1-p=(1-|b_0|)^T$ we can obtain the value of T which approximately equals to five. Therefore a five-year moving average can be found to proxy the "sustainable" or "permanent" values of the fundamental variables. Next the estimated ERER can be found. Finally we also find that the error term of equation(5) is stationary. The regression and ADF unit-root test results are showed in Table 5.

Table 5 Results of ADF Unit-root Test for Error Term of Equation(4) & (5)

	ADF Test Value	MacKinnon Critical Value
Equation(4)	-3.429*	-3.00
Equation(5)	-3.623*	-3.00

** The value is significant at the level of 5%.*

3.6 IMPLICATIONS OF THE PARAMETERS OF ALL FUNDAMENTALS

The equilibrium real exchange rate of RMB is determined by the combination of individual effects of the fundamentals. Although China's government gradually liberalizes the exchange rate of RMB, still there are a lot of things for China's government to do to improve the behavior of the real exchange rate of RMB. From Table 4 we can see that the parameters of LOPEN and LPRO are negative, while the others are all positive.

Table 4 shows that the coefficient of LGOVE has the biggest value among all the five fundamentals and this is also the only value to measure how the government's behavior can affect the movement of the real exchange rate of RMB. To tell the truth, China's economic development in some degree depends on the stimulation from the

① Other coefficients are not needed in this paper so they are not listed here.

expenditure of government. Only if the government spends its money mostly on non-tradable goods, the coefficient sign of this parameter can still be positive, otherwise plenty of government consumption will only cause the depreciation of the exchange rate instead of the appreciation. Table 4 also shows that the coefficient of LTOT has the second biggest value among all the fundamentals, which means that the improvement of TOT will bring obvious appreciation to the exchange rate of RMB. However, under the current circumstance of international trade China is still a price-taker, so TOT is an exogenous variable for China. Another parameter that has a positive coefficient is the variable of NKI. Although the value of this coefficient is not as big as the other two mentioned above, its influence can't be ignored because this fundament itself usually has much larger value especially for today's China. In 2005 China's net capital inflow has arrived to more than 46 billion USD, and in 2006 China's government is expecting that this number will reach 60 billion USD. Undoubtedly a huge number of NKI will increase the potential for RMB's appreciation.

Most of the variable estimates are seemingly consistent with the theoretical prediction for their impacts on the movement of equilibrium real exchange rate except for the variable of PRO. It is interesting for us to find from Table 4 that the variable of PRO has a negative coefficient, which should be positive according to the theoretical prediction. As we have said above, only if the productivity progress for tradable goods relative to non-tradable goods in one country is growing faster than that in other countries of the world, the currency of this country is able to experience the appreciation in the long run. As to China, even though the exportation of tradable goods has been increasing rapidly in recent years, this kind of growth is mostly based on the rapid development of the export-oriented foreign companies and the much

lower labor prices. The technology progress and productivity elevation in the section of tradable goods are not proportional to the rapid growth of the exportation of tradable goods in China. The technology progress in the section of tradable goods has been boosting the economic growth to some degree in China, which mainly results from the technologic overspills from the section of nontradable goods. Meanwhile the productivity improvement of the production factors in the section of tradable goods doesn't have an obvious contribution to the economic growth in China. That is, the section of tradable goods hasn't adopted more advanced technology than the section of non-tradables so that the productivity in the section of tradable goods is not higher than the section of non-tradables.[①] So naturally the productivity progress won't bring the appreciation of RMB for China. From this point of view the negative sign of this parameter doesn't contradict with the theory prediction. Furthermore, although Elbadawi didn't nail down the fundamental of technologic progress in his model, he really pointed out the influence of this fundamental indirectly in his analyses. As the point of view of Chilly, the sign for the fundamental of technologic progress is negative too.

3.7 ANALYSES TO THE MOVEMENTS OF ERER AND REER

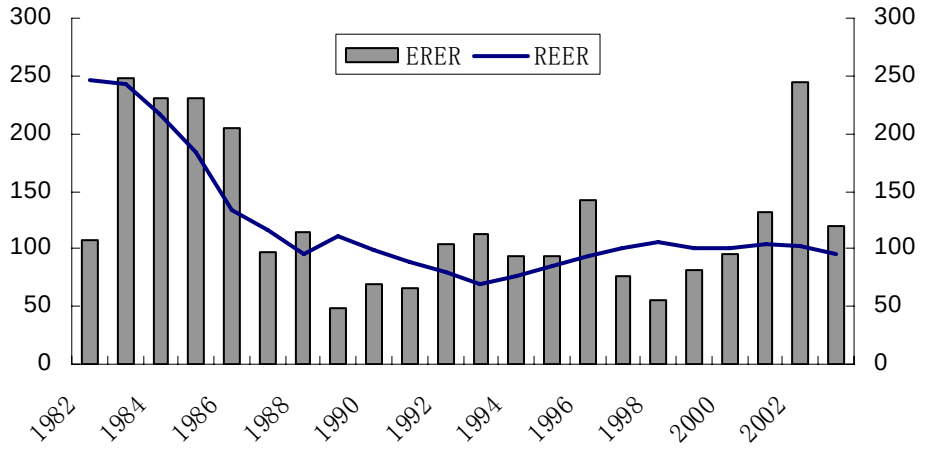
Based on the estimations of all the parameters we can calculate the long-run equilibrium real exchange rate. Table 6 shows the data of real effective exchange rate of RMB and the estimated equilibrium real exchange rate.

[①]Bao Qun, Xu Helian & Lai Mingyong. *How the Exports Accelerate the Economic Growth.* Economic Research of Shanghai, 2003

Table 6 REER and Estimated ERER Index of RMB from 1982 to 2003

Year	REER	Estimated ERER
1982	246.614	107.263
1983	242.465	248.084
1984	216.11	230.133
1985	183.368	231.306
1986	133.492	204.365
1987	115.633	96.939
1988	96.21	114.195
1989	110.927	48.424
1990	98.872	68.690
1991	88.201	66.620
1992	79.269	104.450
1993	70.087	112.858
1994	76.038	93.216
1995	84.723	93.944
1996	93.211	141.553
1997	100.363	76.975
1998	105.692	55.389
1999	99.968	81.516
2000	100	96.150
2001	104.297	132.222
2002	101.888	244.721
2003	95.205	120.100

Figure 2 Movements of REER and ERER



With these data, Figure 2 can be drawn. This figure represents the movements of

REER and the estimated ERER for the period from 1982 to 2003. When REER is above or below the estimated ERER, it indicates that the real effective exchange rate is overvalued or undervalued. Here we define the deviation of actual REER from the estimated value of ERER as the short-run misalignments.

The misalignment of the exchange rate of RMB, as showed in Figure 2, tallies with the macroeconomic development in China. From the Figure 2 we can see that the exchange rate of RMB was overvalued from the end of 1980s to the first two years of 1990s basically because China was experiencing the high inflation during this period which resulted in the speedy heightening of the real effective exchange rate of RMB. Meanwhile, the increasing openness of China also lowered the equilibrium real exchange rate of RMB. Consequently, the trade surplus of China shrank from about nine billion dollars in 1991 to 5 billion dollars or so in 1992, declining almost 50%. But after the year of 1992, the exchange rate of RMB started to be undervalued till the year of 1996. The highly increase of net capital inflows was the main reason to explain the revaluation of exchange rate of RMB for this period when other conditions didn't have obvious change. Statistic data shows that the yearly average of net capital inflows from 1992 to 1996 is four time higher than the yearly average of previous three years. From the year of 1993, the exchange rate on FEACs, which was decided mainly by market force and much lower than official exchange rate of RMB, began to have more and more proportions in the computation of the real effective exchange rate, which to some extent lowered the real effective exchange rate of RMB. And the exchange reform in the year of 1994 also devalued consciously the official exchange rate of RMB on the consideration of improving China's export. The undervaluation of RMB during this period boosted China's export and realized trade surplus of more than seven billion dollars in 1994. In 1997 the trade surplus of China

even had a record performance of more than 46 billion dollars. At the same time the outbreak of Asian Financial Crisis depreciated many countries' currencies around China and this wave of depreciation naturally influenced China's economic development. Because China's government promised not to devalue RMB, the exchange rate of RMB started to peg on US dollar. As a result of it, the appreciation of USD also brought about the revaluation of the real effective exchange rate of RMB. During this period, the amount of net capital inflows swiftly declined and even became the net capital outflows, which led to the higher depreciation of the equilibrium real exchange rate of RMB. But from the year of 2000, the equilibrium real exchange rate of RMB started to be revaluated step by step and the real effective exchange rate of RMB also began to move from higher than the equilibrium real exchange rate to lower than ERER. Particularly in the year of 2002, as showed in Figure 2, the equilibrium real exchange rate of RMB appreciated a lot and it was also in this year when the world increasingly demanded revaluation of RMB.

IV. CONCLUSIONS

According to the study of this paper we can conclude that at least it is not empirically credible to test PPP relationship between RMB and USD because some data needed about China is not able to obtain. That is why this paper doesn't put more attention on the PPP theory but concentrate on another way to estimate the equilibrium real exchange rate of RMB which is mainly based on the model of Elbadawi (1994) whose methodology is more practical and suitable for the developing countries like China. Interestingly, most of the studies of this paper agree with the theoretical expectation except that the coefficient of PRO is negative, which is contrary to some of the

research. But in case of China this deviation is mostly because the productivity in the section of tradable goods is not higher than that in the section of nontradable goods, even though the productivity in the section of tradable goods has really been improved to some extent during the past of years. By comparing REER and estimated ERER of RMB this paper draws the conclusion that there are true short-run misalignments of China's real effective exchange rate. Typically from the year of 2000 REER began obviously to be under the estimated ERER, which meant that the exchange rate of RMB was undervalued during this period. Therefore, although the misalignments of exchange rate of RMB are basically consistent with China's macroeconomic developments, China has to reform the exchange rate policy of solely pegging on USD. Otherwise the short-run misalignments may deteriorate and hence become one of the restrictions on China's further economic development.

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